Soundscapes:
A hybrid (sound) book for anxiety

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Abstract
Emerged in later 2019, the COVID-19 pandemic caused several impacts on the economy, society, and lifestyle. Because of a context of fear, unpredictability, and compulsory social isolation, mental health diseases such as anxiety and depression have increased greatly all over the world.

The lockdown enforced the use of online technologies for work, education, entertainment, and socializing. However, some studies already show that excessive screen time often leads to states of anxiety and addiction.

The purpose of this study is to evaluate the relaxation effects from the use of a hybrid sound book that uses printed electronics to allow the reproduction of nature's sounds. Additionally, a set of gestures was established in order to investigate if they would be considered intuitive or not.

The design process was divided into three phases: exploratory research, for gathering information about the topic; ideation, defined by the experimentation of ideas and concepts and prototyping, whose objective was to establish affordances and types of interactions; and testing, which target the evaluation of usability and user experience.

The final prototype was tested by six participants. Although only a few participants demonstrated comprehension of the affordances proposed, mostly considered to have high levels of pleasure and excitement while using it. These findings indicate that the prototype "Soundscapes" can act as an alternative for entertainment and stress relief at home by manipulating a physical paper while exploring touch and pressure in the object itself.

Keywords
Mental health, Hybrid Books, Printed Electronics, Interaction Design, Tangible Interaction

1. Introduction

COVID-19 was first identified in December 2019 in the city of Wuhan, China. Later in January 2020, the World Health Organization (WHO, 2020) declared a state of a public health emergency, and it was also around this time that the WHO warned that this crisis was generating anxiety and stress in the population.

Quarantine was imposed by governments as a measure to prevent, contain and spread the virus (Brooks et al., 2020). There were a few studies (Bai et al., 2004; Wu et al., 2009;

Wang et al., 2011; Liu et al., 2012; Sprang & Silman, 2013) regarding those who stayed in quarantine versus those who did not, where the results were concise with each other. A large proportion of individuals who were quarantined reported anxiety symptoms (DiGiovanni et al., 2004), which in the long term are shown to be quite damaging and long-lasting (Brooks et al., 2020).

Anxiety refers to the brain's response to danger, a stimulus that the body actively tries to avoid. This brain response is a basic emotion, present in childhood and growing up, with expressions ranging from mild to severe (Beesdo et al., 2009). Naylor et al. (2012) shows that people who suffer from mental health problems are more likely to experience physical health problems such as diabetes and coronary heart disease, have a shorter average life expectancy than others, and are more likely to use alcohol or drugs.

The major factors reported for increased anxiety during the quarantine were based on the duration of quarantine, fear of infection, frustration, boredom, concern about supplies and food and not getting adequate information about this disease. After quarantine, it is observed that finances and stigma are the main factors for increased anxiety. To mitigate these effects it is suggested: shorten the days of quarantine, give necessary information to people, provide adequate supplies, reduce boredom and improve communication and pay special attention to health professionals (Brooks et al., 2020).

As people remain physically distant during quarantines and spend more time at home, the use of the internet, cell phones, and other electronic devices increased (Unep, 2021). However, this excessive consumption of technology can affect an individual's physical and mental health (Caplan, 2007; World Health Organization, 2014; Li et al., 2021). Addiction to cell phones and others can cause sleep problems (Sahın et al., 2013) but also increase anxiety and depression. This type of addiction can be associated with loneliness, leading to boredom proneness and consequently reducing an individual's self-control mostly in adolescents and young adults (Shen & Wang, 2019; Li et al., 2021). With this, and to mitigate these types of addiction problems and help to cope with anxiety and depression, it has been identified as an opportunity to create an entertainment and self-care moment away from smartphones and computer screens based on tangible objects that motivate physical manipulation and stimulation of senses other than sight. Thus, it was thought to create a hybrid book that activates sounds of nature in its physical manipulation, to explore the potential of this object as entertainment that improves health and mental well-being.

The hybrid book is the symbiosis between a print and a digital book (Rosária, 2019). In its physical form, it resembles a printed book but contains a digital layer, so interactivity can be integrated into this object by inserting video, sound, or animations through augmented reality (Schmalstieg & Hollerer, 2016) or even through printed electronics, such as using conductive ink.

Multimodal stimulation can be used to enhance relaxation experiences and improve well-being (Nijholt et al., 2010). Paper is a tangible object that is immediately receptive to the execution of actions and has some advantages, characteristics, and affordances that other graphical interfaces don't have and that can be used as a provider of tactile feedback that can increase a state of calmness in individuals. However, it also has the advantage of being thin, light, flexible, porous, and it can also have different levels of roughness. In addition, it has different types of physical affordances depending on the functionality and context of use (Sellen & Harper, 2003).

There are many complementary interventions used alongside pharmacological and nonpharmacological treatments regarding anxiety, as the use of multisensory stimulation (MSS) (Moghaddasifar, et al., 2019). MSS is very much used as a method of rehabilitation treatment in older adults and patients with dementia or Alzheimer's (Ozdemir & Akdemir, 2009; Vazini Taher, et al., 2015) because it stimulates the reticular activating system promoting brain healing which consequently reduces the risk of sensory deprivation and facilitates the improvement of various responses in patients (Moghaddasifar, et al., 2014).

However, since the MSS method uses visual, auditory, tactile, olfactory, or gustatory stimulations it can also be useful for treating anxiety in people of all ages and be a mood regulator (Canbeyli, 2010). Those stimulations can be provided by using lights, music or sounds, palpable objects, and even taste (Staal, et al., 2007).

Regarding the sounds, some are proven to induce and help to achieve a relaxed state, which we were looking for in this project. Natural sounds are perceived as pleasant while the typical technological sounds of urban environments are perceived as unpleasant (Brown & Muhar, 2004; Nilsson, & Berglund, 2006). Several studies have shown, using visual and sound stimuli, that natural environments have a positive effect over urban environments, the positive outcomes include the increase of well-being by inducing positive emotional states and therefore decrease physiological stress responses (Ulrich, 1984; Van den Berg, et al., 2007; Grinde & Patil, 2009).

In this project we present "Soundscapes", a hybrid book that uses the haptic properties of the paper, bringing the richness of this component as a physical device combined with nature sounds to help reduce stress and anxiety at home. This study aims to explore the user interaction with digital content by using auditory and tactile stimulation as the main senses.

2. Design Process: How interaction design helps mental health during COVID-19's restrictions

The development of this project consisted of three phases: the application of a questionnaire and semi-structured interviews about mental health and social isolation, and an exploration of benchmarking focused on different forms of interactive printed books; sketching and prototyping; and testing.

2.1. First Phase: Understanding user context

To confirm the insights from the literature review about the mental health impacts of COVID-19 and to identify which group of participants would be most affected, a questionnaire was created, followed by a semi-structured interview. Thereafter was made a benchmarking exploration-based of interactive printed books. The result of these methods generated a target group, represented by a persona.

2.1.1. Understanding user's behaviors in COVID-19 confinement

A questionnaire was created to identify which group of people would be more susceptible to presenting symptoms of emotional fragility in the pandemic context. It was expected that the results of this method confirmed the data obtained from news and articles. The questionnaire was developed in Google Forms, shared on online platforms, and had the participation of 40 people. It consisted of multiple-choice questions about mental health and the questions were presented on a Likert Scale from 1 to 5. The main goal of this method was to understand the thoughts and behaviors of the participants while at home in the context of social isolation. In the end, it was also presented general questions about the demographic profile of the participants.

The results identified that women from 21 to 29 years old (43%), expressed a higher level of emotional stress. Most of them reported being lonely (88%), even those who declared living together with relatives or a partner. The aspects that these participants considered that affect their mental health the most were dissatisfaction with themselves (43%), the effects of the pandemic (27%), and social networks and technology (16%).

Given the context of social isolation, the participants maintained their mental well-being at home by practicing physical exercises (31%), avoiding social networks (27%), and watching movies and series (21%). Regarding mindfulness practices, most of them reported having practiced meditation or at least have already tried it (86%).

Female participants from 21 to 29 years old reported greater loneliness, stress, and dissatisfaction, emotional states that may or may not be related to social isolation at home due to COVID-19. However, as recent studies have shown, prolonged social isolation alone may worsen such symp-

toms.

These findings suggest that people feel stress and anxiety by the confinement at home imposed by COVID-19 restrictions. They tend to use media as entertainment as a way to relieve them. However, it may support the hypothesis that the screen time of electronic devices and excessive use of social networks and technologies can lead to some level of exhaustion and negatively affects mental health.

2.1.2. How the COVID-19 restrictions affected women

Since female participants reported greater levels of emotional fatigue according to the questionnaire results, a semi-structured interview was conducted online with 5 participants between 21 and 19 years old. The objective of this interview was to understand the behavior of these women to relieve the stress of confinement at home. The questions were designed to gather opinions about mental health, to find out how the pandemic restrictions changed their mental well-being routine, and how technology and electronic devices motivated, positively or negatively, changes in their humor.

Regarding the opinions on mental health, the interviewees attributed mental well-being as a result of routine and management of feelings. The increase in the usage of smartphones and social media while at home, driven by the need for social connection and distraction from confinement was reported by most of them.

Moreover, they were able to identify the decrease in their mental health well-being motivated by the higher usage of screen time and reported increased anxiety in anticipation of notifications and messages. Two interviewees revealed that they physically isolate their phones in another room to focus on other tasks.

The results of the semi-structured interview emphasized the importance of mental health and also a significant correlation between the excessive usage of smartphones, computers, and social media and the increase of negative feelings. Next, a persona was created, with a brief description, lifestyle, goals, frustrations, and needs to contribute to the ideation phase and to represent this target group.

2.1.3. Reducing anxiety by reducing the use of electronic devices

What emerged from the results was a correlation between prolonged home confinement and mental health decline because of the excessive use of electronic devices and the extended online content they offer. Therefore, although the main purpose is to distract and entertain it can provoke anxiety.

That suggests a form of entertainment out of the dispersive online environment represented by smartphones, computers, among others, that contributes to reducing anxiety at home. In this sense, a form of autonomous hybrid interaction, that offers the benefits of the physical touch, and the surprise component offered by the digital content, seemed an alternative with the potential to be developed.

Looking back at traditional media, the exploration of a book as an interface started in this ideation phase. The further experimentations aimed for creating a way of entertainment for mental health purposes, through multisensory stimuli and the application of developing technologies.

2.1.4. Benchmarking

The focus of this phase was to find projects that were related to books in different levels and depths of interaction, from physical to digital.

“Sensory Fiction” (Heibeck et al., 2014) composed of a vest and an interactive book, is an exploration in augmenting emotions in readers by using a wearable system that stimulates physiological responses while interacting with the story. The relevance of this project is based on the possibilities of interacting with the content of a story by using emerging technologies that can associate body and physical sensations.

“Blink” (Kelaidis, 2017) and “Elektrobiblioteka” (Wegrzyn, 2012), integrates digital content into physical books via circuits printed in conductive ink. These projects generate a hybrid book with the look and feel like a traditional version while offering a non-intrusive multi-sensory reading experience. While in “Blink” (Kelaidis, 2017) new content

composed of text, images, and/or animation is shown on the screen of a computer with a click of a button printed on a page, in "Elektrobiblioteka" (Wegrzyn, 2012) digital content is shown when the pages are turned. What is remarkable about these hybrid books is the idea of a paper-based product with digital capabilities based on printed electronics.

"T-book" (Technische Universität Chemnitz, 2021) is a photo book with speaking images. When the pages are turned, the sensors activate sounds. The relevance of this technology is represented by further developments of novel concepts for sensors that are lightweight and flexible, providing another layer of experience with papers and books.

Regarding the physical aspects of the paper, "This book is a planetarium" (Anderson, 2017) is a pop-up book that allows readers to build and use gadgets made by paper folds. Each turn of a page reveals a different paper structure that forms a small projected planetarium, a musical instrument, a sound amplifier, and others, offering a unique object made of paper that invites interaction and physical manipulation. This demonstrates that there is already enough technology available to develop a paper interface with digital components and beyond that. In addition, using printed electronics makes it possible to preserve and explore its physical characteristics, from touch to texture, while accessing another layer of the reading experience with senses.

2.4. Second Phase: Paper experiments

A couple of sketches and paper experiments were made until a low-fi concept could be considered as a working basis. Second, an exploration of areas of touch, functionalities, and tasks was defined.

Followed by the discoverings of the previous examples, four concepts were developed on this exercise (Figure 1). They had a common purpose of generating ideas of books and paper folds, shapes, and forms of activating sounds by using printed electronics and programming.

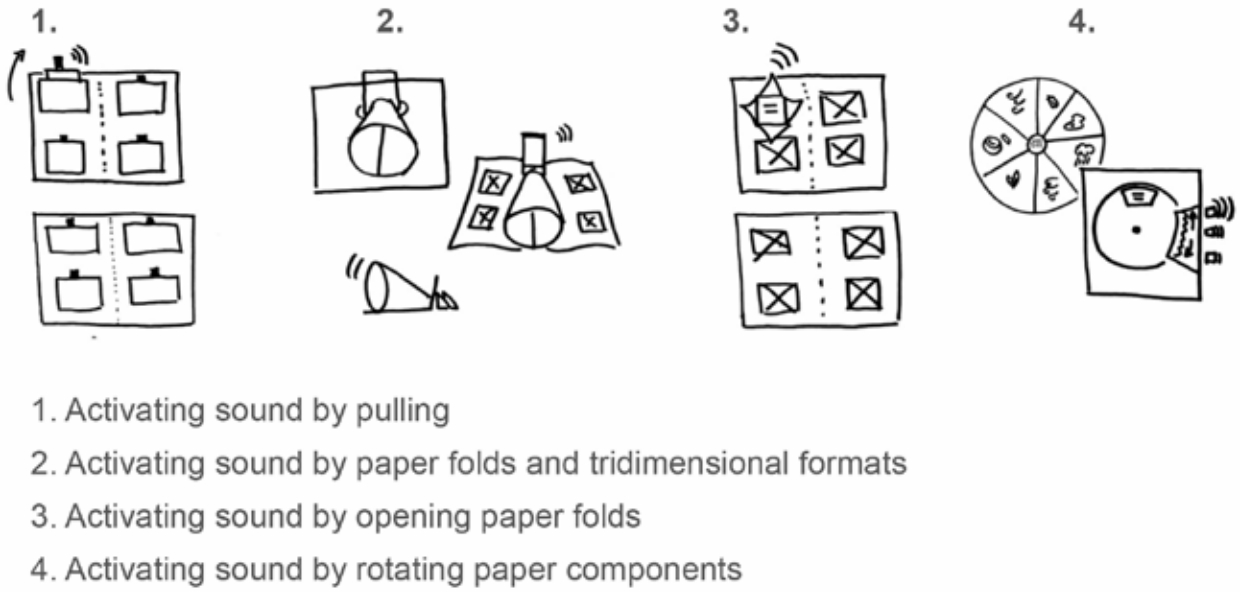

Figure 1. Sketches of folds, shapes, and forms of activating sounds.

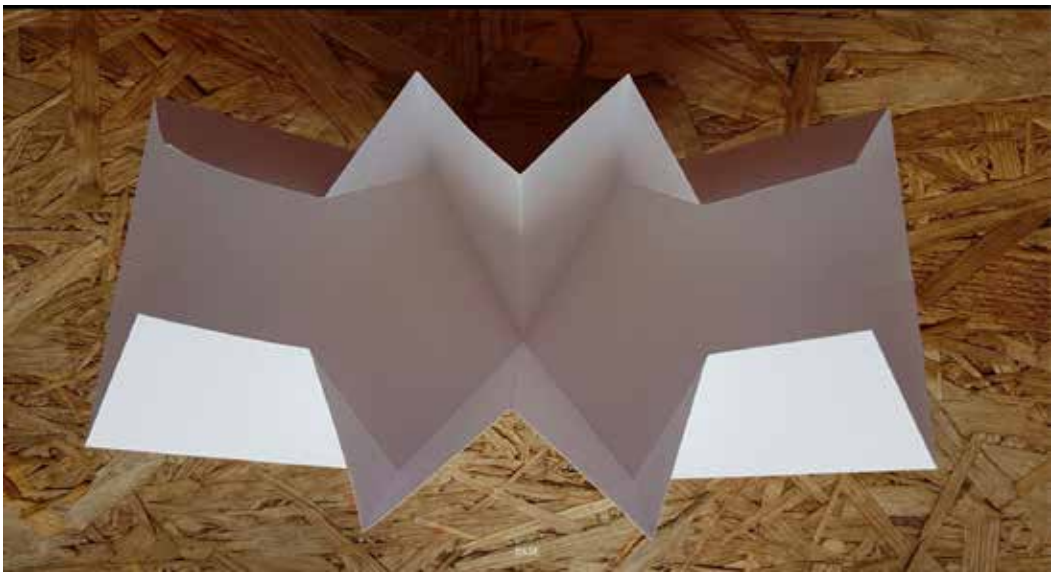

Figure 2. Sample of a Turkish fold made from a single sheet of A4 paper.

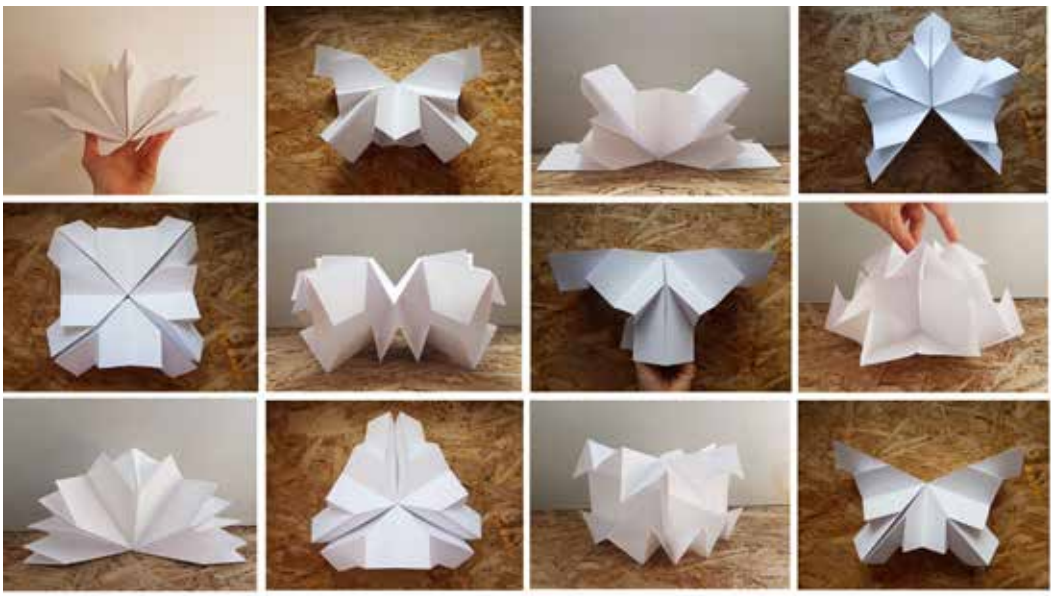

Figure 3. Examples of folding experiments.

2.4.1. The folds

For a more refined physical manipulation of the material combined with the sonorous performance, it was identified that it was required to add volumetry and expand the range of interaction with the object's physicality. For this reason, a process of experimenting with paper folds and origami began, defining the Turkish fold (Figure 2) as the model for the final prototype.

The transition from the first paper models to the creation of the Turkish fold conferred plasticity and a material characteristic that stands out for the discoverability of the opening and closing of the folds. From this unit, a collection of paper sculptures was created (Figure 3).

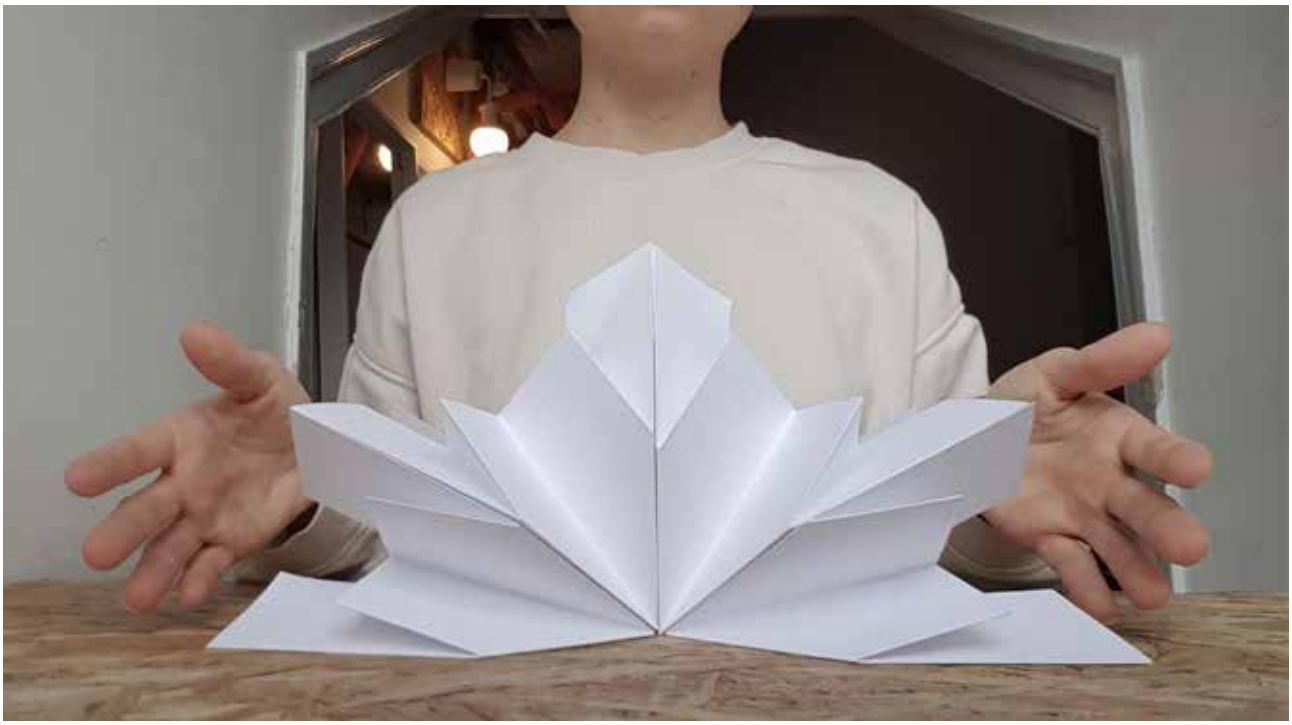

Figure 4. Final model using three Turkish folds altogether.

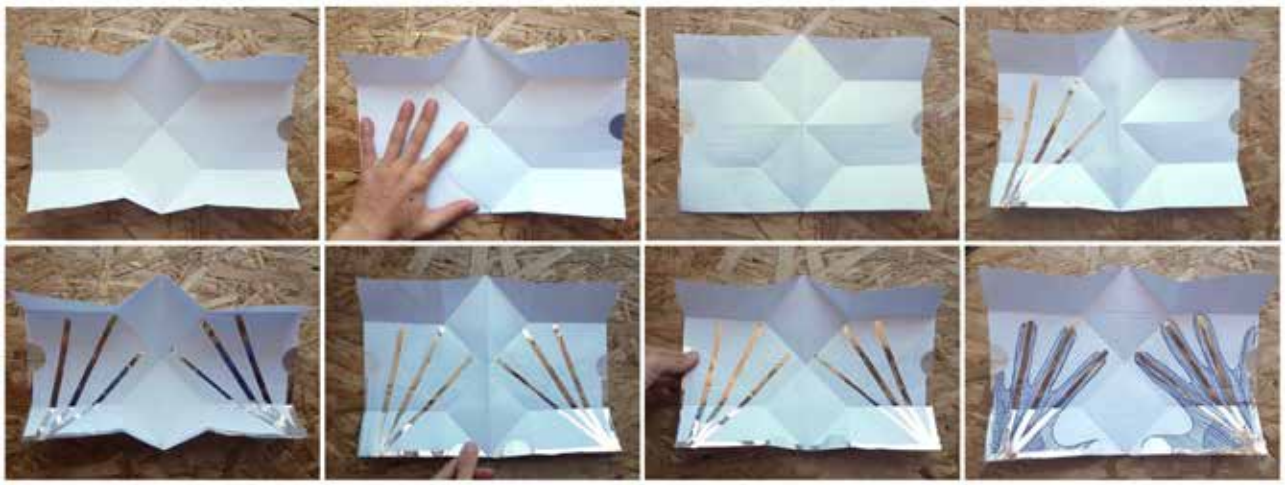

Figure 5. Exploration of the areas of interaction, touch, and pressure.

In order to bring resemblance to a conventional book format, to attend production viability and compressibility, a model was chosen (Figure 4).

2.4.2. Exploring sound and touch interactions

Once the format of the sound-book was chosen, the following phase consisted of establishing the type of interaction and the affordances for sound activation. First, it was

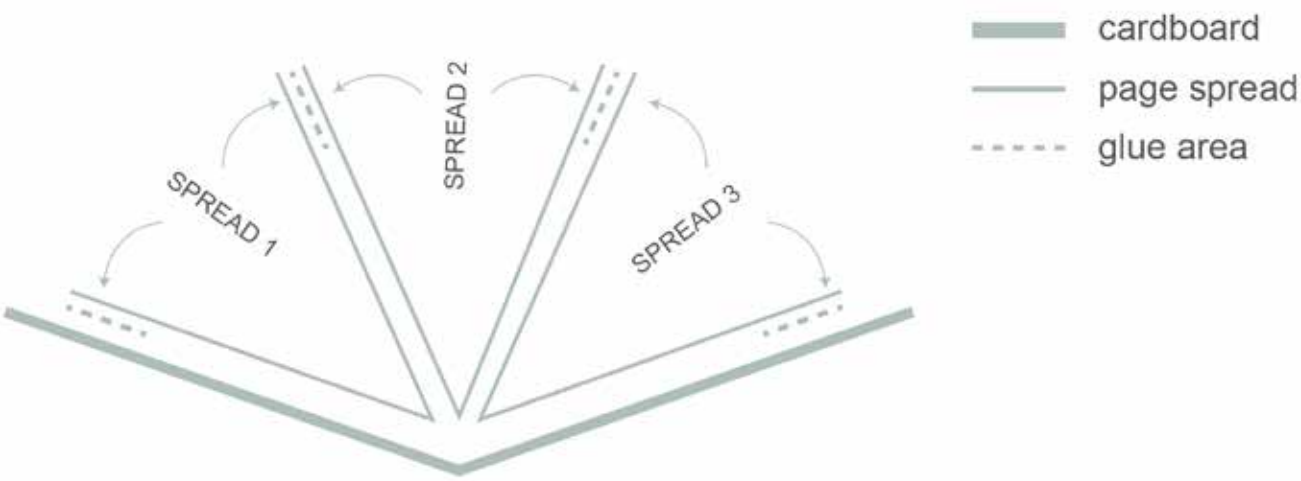

Figure 6. Bookbinding.

defined the area which was seen as the most intuitive for the use of the hands-on pair of pages. Next, it was decided what kind of manipulation would feel more comfortable for touch and finger placement (Figure 5).

The type of interaction was defined by touch and pressure on each spread, determined by the activation of simple sounds and the combination of these sounds into one composition, where each spread would be programmed for presenting two simple sounds and one mixed composition. The reason for deciding on this system was based on the analogy of using hands and fingertips as a common gesture for turning or opening pages of a conventional book.

Three-page spreads were grouped in bookbinding (Figure 6). The first two were chosen to simulate the activation of the audible content. It was determined that each area designated for touch would correspond to the area of placement of the printed sensors.

Two ways of activating simple sounds were defined. The user would have the option to press the left and right buttons placed on the sides of the pages with both index and thumb fingers simultaneously to listen to one simple sound (Figure 7) or by pressing both index fingers on the bottom left and right of the pages to listen to the other (Figure 8). For creating a composition with both simple sounds, it was established to use both hands on each spread, placing index fingers and thumb simultaneously on each button (Figure 9). All the interactions and related sounds are shown in Table 1.

Defining the type of interaction was important not only to investigate if the affordances and functionalities proposed are comprehensible and attractive to the users but also to simulate the printing areas where this technology would be available.

Spread	Activation	
	Button Location	Gesture
Cover	Right edge	Open right to left
Spread 1	Right and left edges	Pressing with fingertips (Figure 6)
	Bottom right and left	Pressing with fingertips (Figure 7)
	Bottom and edges	Pressing with fingertips and thumbs (Figure 8)
Spread 2	Right and left edges	Pressing with fingertips (Figure 6)
	Bottom right and left	Pressing with fingertips (Figure 7)
	Bottom and edges	Pressing with fingertips and thumbs (Figure 8)
Spread 3	No activation	

Table 1 - Prototype functionalities with spread, activation, and sound.

Figure 7. Activation of sounds by pressing with fingertips on the edges of each spread.

Figure 8. Activation of sounds by pressing with fingertips on the bottom of each spread.

Figure 9. Activation of sounds by pressing with fingertips and thumbs of each spread.

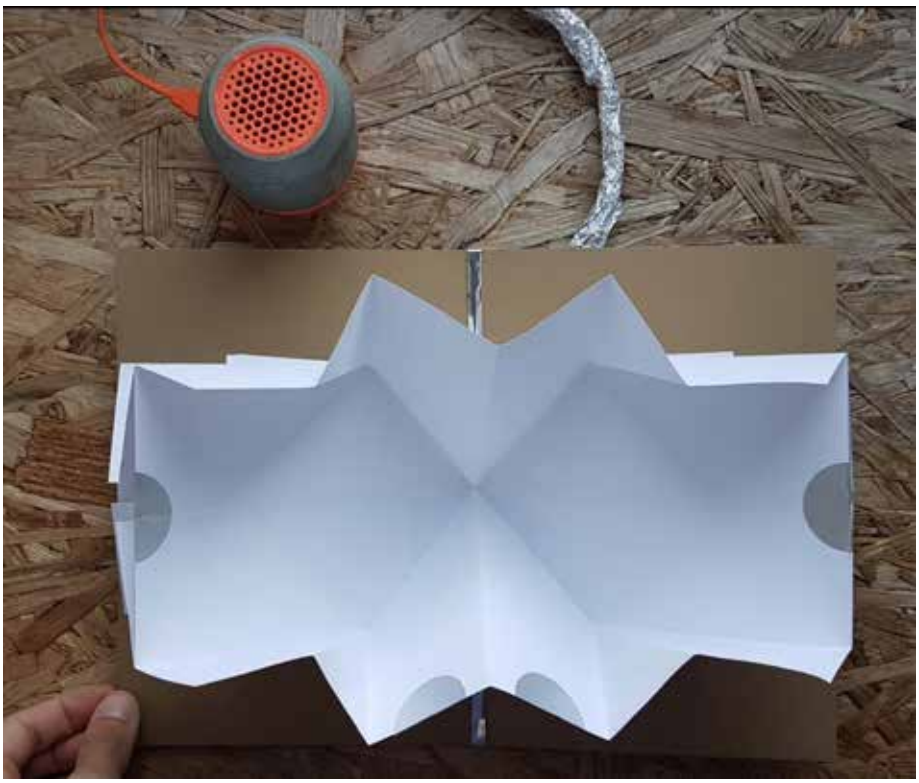

Figure 10. Prototype - Final version for testing.

2.4.3. SoundScape: The Final Prototype

Once the type of interaction and the areas of touch were defined on the paper prototype, the next step was to create a detailed version to be tested with users, in order to evaluate if the affordances were adequate for the user, to effectively perform the sound activation tasks. The final prototype (Figure 10) consisted of a 148 x 210 mm hardcover book with 3 spreads glued to each other. The cover was made of 350g cardboard, and the interior pages were made of 240g white supreme paper.

A metallic adhesive paper was applied in certain areas to signaling where they should be pressed with the fingers, to simulate the electronic sensors. In addition, a Bluetooth soundbox was attached to the sound book, as a reinforcement for the users' perception that the object has a sound component.

2.5. Third Phase: Testing

The testing phase had the overall objective of evaluating the user experience of the final prototype, named "Soundscapes". The goals of Usability and UX then were based on evaluating the understanding of the affordances designed and the task of activating simple and compound sounds. Regarding Emotional Design, it was important to collect impressions of calmness and motivation while interacting with the prototype.

The evaluation consisted of the simultaneous application of three methods: Wizard of Oz (WOz) combined with Think Aloud Protocol, and Self-Assessment Manikin (SAM), and it was conducted on-site and involved six participants, most of them being women between the ages of 21 and 29.
It proceeded with the preparation of the interaction scenario, setting metrics for tasks and corresponding success, defining relevant questions, and applying an emotional scale. After the tests were made there were some adjustments pointed and observed to adjust in the future.

2.5.1. WOz and Think Aloud Protocol

WOz method was chosen to simulate the functionalities of the prototype, to understand how the affordances were understood by the participants as well as their product experience. While the application of the Think Aloud Protocol in association with direct observation aimed to motivate the participants to verbalize their impressions throughout this interaction and observe their manipulation behavior.

The questions addressed to the participants had the purpose of generating insights at the level of affordances evaluation. In this sense, the form of presentation of the prototype is related to the expected form of use, what are their first impressions, and if they were successful in activating the sounds. The test consisted of manipulating the object and delivering questions according to the participants' performance throughout the experience.

Concerning the task of opening the book, all participants were successful in opening the book and recognizing the opening sound. The presence of the Bluetooth speaker contributed to creating the expectation to listen to a sound when opening it. All the subjects expected to have a sound experience at some level.

Regarding sound activation, it was found that the affordances attributed to the sound activation sensors, represented by the metallic adhesives, were not evident to the users. Two participants triggered the simple sounds on the sides of the pages with a light touch, accidentally. One participant, who triggered the simple sounds from the bottom of a page spread, thought it was purposeful as the position favored the idea that it is like a watercourse running down. The three participants who activated the simple sounds noticed that when they turned to the next page and applied the same gesture, they would hear another sound. Since they figured that each page had a different sound output, they failed to explore it sufficiently enough to realize it was also possible to combine them. In the end, they all turned off the book in the same manner, with the same gesture as conventionally it is used to close a traditional book.
The combination of these two methods, along with direct observation, resulted in several indications that emphasize the necessity to adjust the affordances of the prototype as well as the conditions of application of the evaluation. Giving more clear visual and haptic cues, expanding the use of the hands, and providing instructions as support are some suggested changes for the future.

2.5.3. Self-Assessment Manikin (SAM)

After the application of the WOz and Think Aloud methods, the participants were requested to rate the amount of pleasure and calmness during the experience. The Self-Assessment Manikin (SAM) was applied, which aimed to determine whether the experience of using the prototype gave the participants a sense of happiness or unhappiness, excitement or calm.

Figure 11 demonstrates the results of the SAM evaluation, in which each participant is represented by a colored circle. About the valence, the majority indicated a pleasant experience, and one participant perceived the experience as neutral. On the arousal scale, a tendency toward high excitement is observed, and only one participant pointed out that the experience delivered a sense of tranquility.

Thus it can be inferred that the experience brought a considerable level of pleasure and interest, and curiosity about the object, rather than a sense of calmness, which was expected to be achieved. This may have been affected due to the fact of not knowing the a priori state of the participants, the test not being applied in a neutral space, and the participants being enthusiastic about experimenting with something new in itself.

3. Conclusions

In 2019 a global pandemic of coronavirus disease affected people and their everyday life all around the world and changes in the economy and also the society was imposed. The lockdown and other restrictions forced millions of people to stay at home in social isolation for months under emotional stress, fear, and anxiety when facing uncertainties.

Soundscapes is a hybrid book that produces sounds of nature through touch and pressure interaction on printed sensors, with the purpose of reducing stress and anxiety at home, during the pandemic. It was created to resignify the book, not only as entertainment for mental health but as a speculative design for the development of a hybrid interface.

Although the affordances created did not perform as expected, and did not lead to a state of calmness as intended, the experience of use led to a state of happiness. Therefore, it is concluded that the object, although lacking any graphic and visual information, had an appeal to the senses of touch and listening. The manipulation of the paper folds was mentioned as "pleasant" by most of the participants and all the sound stimuli including the sound of turning on generated the participant's expressions of surprise, laughs, and curiosity.

In the future, we suggest some design modifications in the prototype and in the testing phase. The design alterations are defined by creating more affordances, with visual and tactile resources, to understand the functionality more clearly and explore new possibilities to interact, not only with touch and finger pressure but also the movements of the hands, on the pages. Moreover, graphic components such as titles, illustrations, and text can impact the user's behavior, inducing a state of relaxation depending on the aesthetics chosen.

Given the proximity of the interviewer to the participant, the results may have been affected by the expectation of validation in the response. Therefore, it is recommended that the test is conducted in an environment where the prototype can be manipulated freely. Next, it is suggested the evaluation process be recorded and include at least two evaluators, one to observe the gestures and activate the sounds accordingly, and another for interviews in order to reduce bias and to contribute to a more natural experience for the participant.

Furthermore, it is critical to consider the limitations of the study such as the fact the participants were not in the appropriate emotional state for the purpose of the project, which can compromise the results. In the future, these tests have to be applied to subjects who are at targeted levels of anxiety and stress, to better assess the solution.

The number of participants should also be increased in order to provide credibility to the observed behavioral patterns of use. Additionally, the opinion of experts in the mental health area is fundamental to understand how the prototype can prevent mental health disorders in an exceptional context such as COVID-19.

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